

[72] Inventor **Costas Stylianos Krikelis**
Englishtown, N.J.
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 [73] Assignee **E. I. du Pont de Nemours & Co.**
Wilmington, Del.

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Primary Examiner—John M. Horan
 Assistant Examiner—Alan Mathews
 Attorney—Lynn Barratt Morris

[54] **PHOTOGRAPHIC DEVELOPING APPARATUS**
4 Claims, 3 Drawing Figs.

[52] **U.S. CL.** **95/89,**
95/94

[51] **Int. Cl.** **G03d 3/00**

[50] **Field of Search.** **95/89, 94**

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ABSTRACT: An apparatus for the continuous processing of an exposed photopolymer litho plate by the successive operations of developing and rinsing through soaking pools and sprays, drying and post exposing to harden the image for use, rehumidifying, and coating the image surface with gum arabic to preserve the plate.

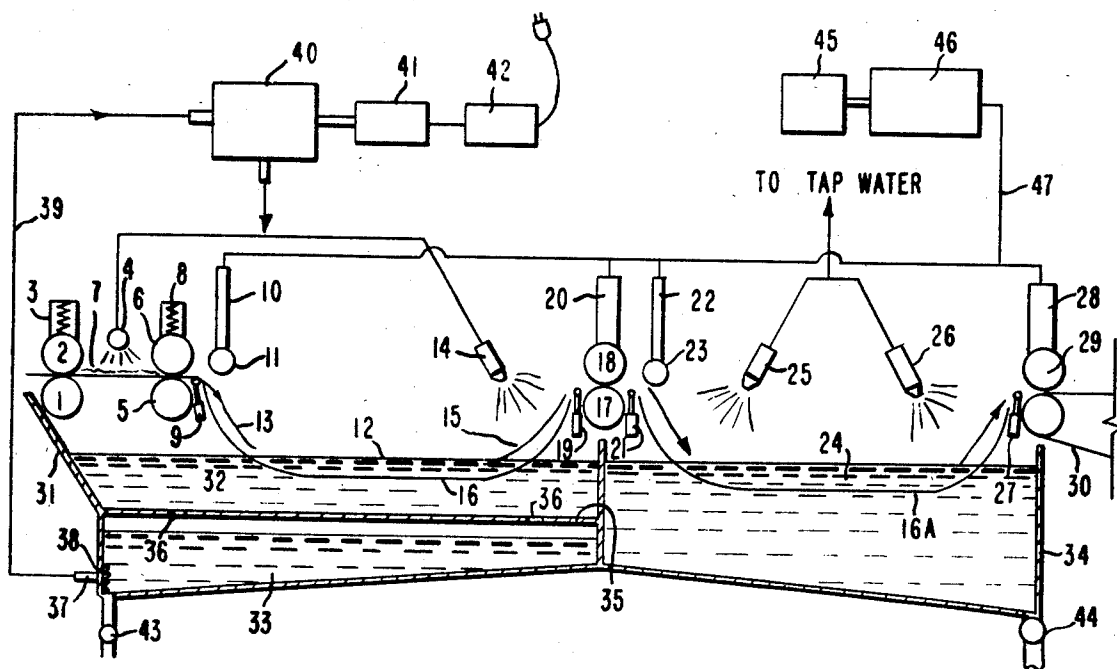


FIG. 1

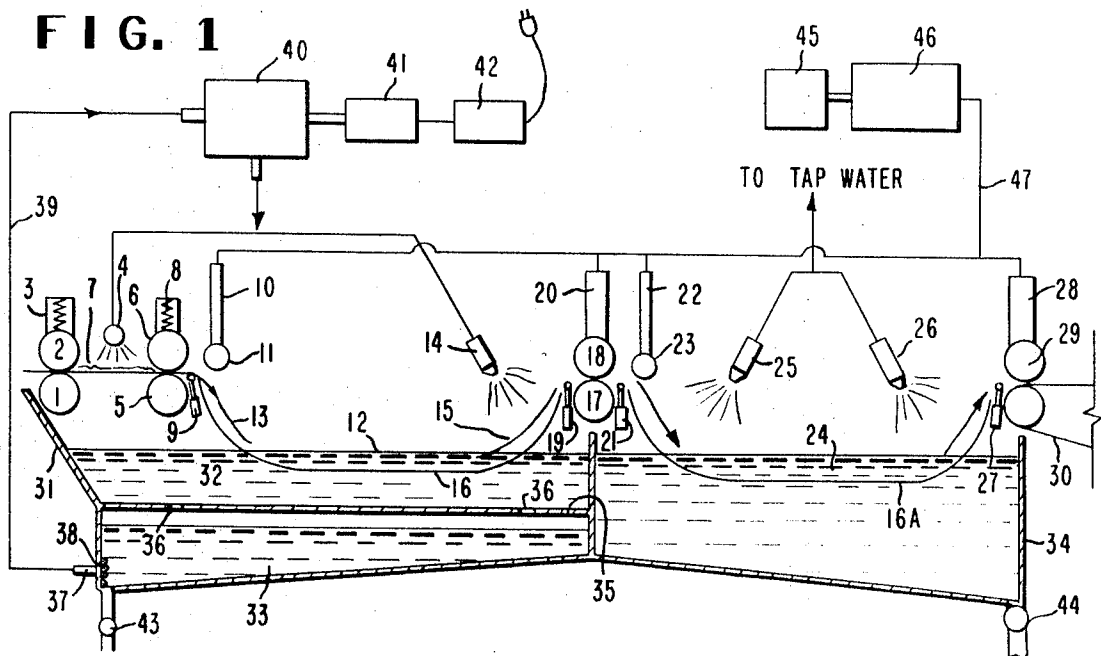
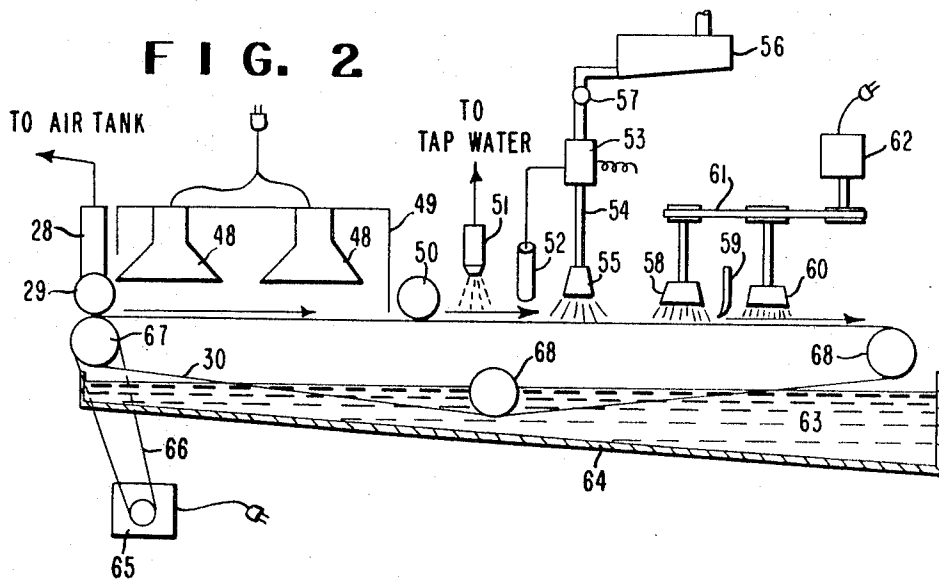


FIG. 2



INVENTOR

COSTAS STYLIANOS KRIKELIS

BY *William B. Gordon, Jr.*

ATTORNEY

PHOTOGRAPHIC DEVELOPING APPARATUS

BACKGROUND OF THE INVENTION

In order to process a photopolymer aluminum lithographic plate, such as that described in Alles, U.S. Ser. No. 560,889 filed June 27, 1966 and the continuation-in-part application to Alles, U.S. Ser. No. 609,732, filed Dec. 15, 1967, title "Photopolymerizable Elements With Solvent Removal Protective Layers" now U.S. Pat. No. 3,458,311, July 29, 1969 an apparatus is needed that will provide an easily controlled, reproducible developing process where the image surface undergoes a minimum amount of physical contact to reduce the chance of damaging the image. The apparatus of this invention accomplishes the development by combining a soaking action provided by a pool of liquid to loosen the unpolymerized material and an erosion action provided by a spray to remove the dissolved unpolymerized material, then the plate is washed.

In addition to the developing and washing cycles, it is desirable to have, in a continuous operation, an alternate embodiment wherein a lithoplate may be further processed by subjecting the plate to a drying and postexposure stage to further harden the plate, and by preserving the plate by a coating of gum arabic. The postexposure and the application of gum arabic may be accomplished in either order.

SUMMARY OF THE INVENTION

An integrated machine for automatically processing an imagewise exposed photopolymerizable element, e.g., a photopolymer coated lithoplate, through a plurality of stations arranged in combination to provide a continuous and complete process, which comprises (a) a developer bath for soaking the element, (b) means for spraying the element with developer before the element enters and as it leaves the bath to aid in the removal of the unexposed material on the plate, (c) a water bath for soaking the element in a pool of water to rinse and desensitize the element, (d) means for spraying the element with water to wash away any excess loose material remaining on the element, (e) means for passing the element through each bath and past each spray, and (f) guide means in each bath to lead the element in a path through each bath.

Alternate embodiments include means for recirculating the developer, and the additional process stages of drying and postexposing, rehumidifying, and the application of gum arabic to preserve the element. The postexposure and the application of gum arabic may be accomplished in either order.

DESCRIPTION OF THE INVENTION

The machine of the present invention consists in the construction and arrangement of parts that will clearly appear from the following description when read in conjunction with the accompanying drawings. In these drawings:

FIG. 1 is a schematic drawing of the developing stage and washing stage.

FIG. 2 is a schematic drawing of the postexposure stage, rehumidifying stage and gum arabic applying stage.

FIG. 3 is a schematic drawing showing an alternate method of conveying the element through the developing and washing stages and the reverse positioning of the postexposure and gum arabic stages.

Essentially, the machine consists of acceptor rolls designed to take a hand-fed imaged photopolymerized element and pass it beneath a developer soaking spray and then feed the element into a second set of dry rolls from which the element exits. Thereafter, the element is immediately flexed downward by a directional roller driven by an air cylinder into a pool of developing solution. In the pool of developer, the unexposed, unpolymerized material on the photographic element is dissolved. As the element is pushed through the developer and exits the developing pool a nozzle sprays developing solution on the surface of the element and removes the now dissolved

material. The path of the element through the developing stage, particularly, the entrance and exit from the developing pool creates a stream of solution running down the incline so that prior to entrance of the element into the developing pool the stream of solution aids in the soaking process of the element and upon exit the flowing solution helps remove any development irregularities such as streaking. This combination of sprays and bath insures complete soaking of the element. The element is washed with tap water in a similar fashion by passing the element in a path through a pool of water while overhead water sprays are impinging on the surface of the element. The element is then passed under a sun-lamp which provides two functions, to first dry the element by the heat of the lamp and secondly to postexpose the material remaining on the element in order to further harden it. The dried element is now rehumidified by an atomizer and passed through a final station where a conventional finishing solution, such as gum arabic is applied.

A photographic element usable in this process is that described in Alles, U.S. Ser. No. 560,889 filed June 27, 1966 (now abandoned, but first refiled as Ser. No. 690,732, Dec. 15, 1967, U.S. Pat. No. 3,458,311, July 29, 1969) and described in Example 1. In general terms, the element consists of an aluminum support coated with a photopolymerizable composition overcoated with saponified polyvinyl alcohol. After imagewise exposure this photographic element may be developed by the following developer solution, 0.2 percent of 10 percent by weight octylphenyl polyglycol ether with a polyether chain length of 9 to 11 glycol units, 2.5 percent of 10 percent by weight $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$, 6 percent of monobutyl ether of ethylene glycol, one drop of octyl alcohol and distilled H_2O (91.3 percent). The developed element is usable as a lithographic printing plate.

A specific embodiment of this machine is shown in FIG. 1 where selected dimensions have been exaggerated to facilitate understanding. Looking to FIG. 1 a photographic element to be developed will be introduced into the machine by placing the lead end of the element between rollers 1 and 2. Roller 1 is journaled into a fixed support while roller 2 is movably mounted under the compressive force of spring 3 forcing roller 2 against roller 1. Number 1 roll is driven and its rotation carries the photographic element under soaking spray 4 and into rollers 5 and 6. Soaking spray 4 emitting a developer solution creates a pool 7 of developer solution on top of the photographic element. The circumference of top roller 6 is undercut in a regular pattern to permit developing solution, from the pool of developer solution, to flow out of the pool through the undercut portions. The photographic element to be developed by this machine is ordinarily a photolithoplate having a rather stiff support so that no conveyor means is necessary to carry the photographic element from entrance rollers 1 and 2 to rollers 5 and 6 although a conveyor may be used if more flexible supports are involved. Furthermore, the distance between the nip of rollers 1 and 2 and the nip of rollers 5 and 6 for processing any given element is made shorter than the length of the element to be processed. Roller 5 is journaled into a fixed support and is driven while roller 6 is mounted in-line and directly above is mounted under the compressive force of spring 8 forcing roller 6 against roller 5.

Microswitch 9 engages the bottom surface of the element as the element leaves the nip of rollers 5 and 6. Microswitch 9 activates air cylinder 10, forcing roller 11 down against the top surface of the film element being processed and flexing the element downward in a path into a pool 12 of developer 13. During the downward movement of the element a turbulent flow 13 of developer moves over the surface of the element helping to carry away material already dissolved by soaking spray 4. While the element is submerged in the pool of developer, the unpolymerized material thoroughly dissolves and is washed away by the action of developer spray 14 which impinges on the surface of the element as the element leaves the pool of developer. The upward motion of the element causes a flow of developer to run back over the element into

the pool of developer. This runback 15 has a smoothing effect tending to eliminate irregularities such as streaking. The path of the element into and out of the pool of developer is guided by concave bottom guide plate 16 while the transporting means of the element through the developer is provided by drive roll 5. It must be appreciated that the length of element to be processed must be longer than the distance between the nip of drive roll 5 and roll 6 and the nip of drive roll 17 and roll 18.

As the element leaves the developing stage it contacts microswitch 19 which activates air cylinder 20 causing roll 18 to move from its normally "UP" position to a downward position against the top surface of the element so that a nip is now formed between rolls 17 and 18 and drive roll 17 is now effective in pulling the element from the developer stage and driving it into and through the washing stage. As the element leaves the nip of rolls 17 and 18 it contacts microswitch 21 which activates air cylinder 22 forcing guide roll 23 against the top surface of the element flexing the element in a downward direction and causing it to move into the washing.

The washing unit is made up of a pool 24 of water with overhead spray 25 to impinge on the element as the element enters the washing unit and spray 26 to impinge on the element as the element leaves the washing unit. The washing unit also has a concave bottom guide plate 16A used to direct the element under the sprays into and out of a pool of water and places the element in a position to be accepted by the next stage in the processing. Spray 25 is designed and directed to give a hard scrubbing action to the surface of the element while spray 26 is designed to give a light rinsing action to the element. The sprays create a turbulence in the pool of water aiding in thoroughly washing the element. Microswitch 27 is located at the exit end of washing unit and is activated by contacting the element. Upon activation a signal is sent to air cylinder 28 which operates to force roller 29 in a downward direction against the top surface of the passing element directing the element along conveyor belt 30.

The equipment used to support the development and washing units comprises a tank 31 having an upper compartment 32 and lower compartment 33 containing the developing solution, and a second tank 34 to contain a pool of water. In tank 31 compartments 32 and 33 are separated by barrier 35 having small drain holes 36 cut into it to allow developer to drip into compartment 33. Compartment 33 has an outlet port 37 covered by a filter screen mesh 38 which allows developer solution to be recirculated through conduit 39 into recirculation pump 40 and out through sprays 4 and 14. Motor 41 drives recirculation pump 40 and variable transformer 42 controls the speed of the motor 41 which in turn controls the rate of flow through pump 40 into the sprays. On the bottom of compartment 33 is a drain valve 43 which permits the disposal of used developer.

Washing sprays 25 and 26 receive their supply of water directly from a tap. The used water is permitted to collect on the bottom of 34 and build up a pool 24 of water used in washing the element. The water passes to a drain through throttling valve 44 which is manually controlled.

Air cylinders 10, 20, 22, and 28 are supplied by a compressor 45 which builds up a reserve tank 46 of air and feeds this air to the cylinder through conduit 47.

After developing and washing, the element is fed onto conveyor belt 30 for final processing. This requires that the element be dried and hardened for use. The hardening process is done by further polymerization of the image while the drying process is accomplished by heat. This may be done in one step by the selection of an appropriate radiation source. If the polymer layer contains a photoinitiator, the same light source should be chosen to sensitize and thereby photopolymerize the image to harden it and also generate enough heat to dry it. If the polymer layer contains a thermal initiator, the radiation source should be chosen to generate enough heat to thermally polymerize the image to harden it and also dry it. In the drawings, numeral 48 designates the light source and 49 designates the protective shield around the light source.

Consider the following as an example of how a proper radiation source is selected. It was found that the optimum wave length required to polymerize the image on a photopolymer lithographic printing plate, as described in Example 1 of Alles, U.S. Ser. No. 560,889, filed June 27, 1966, was ultraviolet radiation with a wave length of about 3110 angstroms. It was also found that heating the plate to 120° C. for one minute not only dried the plate but also aided in hardening the polymer layer. The two parameters of ultraviolet and infrared radiation were found in a sun lamp. An example of one usable sun lamp is the General Electric Type 275 R.S. rated at 275 watts with its main output in the 3,000 to 4,000 angstrom region of the spectrum.

The element advances along conveyor belt 30 underneath roller 50 and into the rehumidifying stage. Moisture is supplied to the element by an atomizer-type spray 51 which receives its supply of water from a tap. Roll 50 preceding the rehumidification cycle is used to keep spray water from striking the sun lamps. After rehumidification the film element passes underneath a sensor such as a photocell 52 that detects the presence of the element and sends a signal to solenoid operated valve 53. Valve 53 opens allowing gum arabic to flow through conduit 54, applicator 55 and onto the film element passing beneath the applicator. The gum arabic is stored in a container 56 and permitted to flow through hand-operated valve 57 into the automatic control system. Brush 58 operating at low speeds, approximately 50 r.p.m., helps to spread the gum arabic evenly over the entire surface of the element. Any excess is wiped away by a wiping blade 59. A set of high speed brushes 60 is used to polish the element. The rotation of the brushes is powered through belt 61 driven by motor 62. During the application of gum arabic some material falls onto the conveyor belt. This material is washed off the conveyor belt as the conveyor belt rotates through a pool 63 of water held in container 64. The conveyor belt itself is driven by motor 65 through belt 66 and drive roll 67. The belt 30 is supported by other rollers 68.

The operation of this machine proceeds as follows. First, all the power equipment in the machine is turned on and continues to operate during the processing of an element. That is to say recirculation pump 40 is turned on and continues to recirculate developer from compartment 33 to developer spray nozzles 4 and 14. Tap water is fed into spray nozzles 25 and 26 setting the washing cycle into operation. Drive rolls 1, 5, and 17 are set into rotation by appropriate means, not shown, to accept an element when it presents itself. Motor 65 is turned on to activate the belt system. Sun lamps 48 are turned on and remain on while tap water is fed to atomizer spray 51. Photocell 52 is activated and motor 62 is also turned on to start brushes 58 and 60 into rotation. With all appropriate elements of the machine on, the machine is now ready to accept an element for processing.

An imagewise exposed photopolymer lithographic printing plate is introduced into the nip of rollers 1 and 2, and carried into the developer soaking stage after passing under spray 4. The unpolymersized material on the plate element begins to soften and dissolve by the soaking action, and the plate moves into the nip of rollers 5 and 6. The rigidity of the plate carries it in a horizontal path between the nip of rollers 1 and 2 and rollers 5 and 6. Contacting microswitch 9 activates roller 11 causing it to move in a downward motion against the top surface of the plate forcing the plate to begin a path into a pool 12 of developer. The downward path of the plate causes a flow 13 of developer to move in a turbulent fashion over the surface of the plate helping to wash away some of the dissolved photopolymer. The plate continues to be driven by drive roll 5, and the plate enters a pool of developer which further softens and dissolves the unpolymersized material. This soaking action is needed to insure proper development of the photopolymer litho plate. The plate exits the pool and is immediately subjected to a developer spray 14 which impinges on the surface of the plate washing away any undissolved material which remains on the surface. The plate leaves guiding surface 16, still being driven by roller 5, and contacts

microswitch 19 which activates top roll 18 which is in a normally up position and causes roller 18 to come down on the surface of the plate forcing the plate to take a horizontal direction guiding it into the washing stage.

The washing stage operates in a fashion similar to the developing stage. Upon leaving the nip of rolls 17 and 18 the plate contacts microswitch 21 which forces roller 23 down on the top surface of the plate flexing the plate and causing it to take a downward path into a pool 24 of water. During its downward travel the surface of the plate is subjected to a scrubbing type water spray 25. This washes away excess unpolymerized material remaining on the plate. The plate progresses through a pool 24 of water and upon exit is subjected to impinging water from spray nozzle 26 which is a spray serving merely as a rinse.

Leaving the washing stage the plate contacts microswitch 27 which forces roller 29 down against the top surface of the plate flexing the plate in a horizontal direction and causing the plate to be fed onto horizontal belt 30. Through the washing cycle the plate is directed by a guide shield 16A and the plate is pushed through the washing cycle by drive roller 17.

Once on the conveyor belt the plate passes under a set of sun lamps which dry and postexpose the unpolymerized material remaining on the plate. The plate is then rehumidified by spray 51 and is then ready for application of gum arabic to preserve the plate. Leaving the rehumidifying cycle a sensor such as a photocell 52 detects the presence of the plate and signals the solenoid operated valve 53 to feed gum arabic through applicator 55 onto the top surface of the plate. Rotating brushes 58 help to spread the gum arabic over the surface of the plate element while the doctoring blade removes any excess gum arabic. High-speed rotating brushes 60 polish the plate. The plate is now ready for use.

In an alternate embodiment, as shown in FIG. 3, the basic method of processing the element by spraying it while it travels in a path through the developing and washing stages is maintained while the means of directing the film in the sinusoidal path has been changed. An additional change has been to reverse the final stages by placing the surface chemical treatment stage before the postexposure stage and eliminating the rehumidifying stage.

In order to accomplish this, input-drive rolls 69 and 70 are set at an angle to direct the element down a guide plate 71. When an element to be developed is introduced into the nip of rollers 69 and 70, sensor 72 senses the presence of the element and activates the developer spray pump 73 which pumps developer solution from the developer tank 74 out through the soaking spray nozzle 75 and onto the passing element. At the same time developer is pumped through nozzle 80.

After soaking, the element feeds into drive rolls 76 and 77 which direct the element along guide plate 71, through a pool 78 of developer solution under spray 80 and over sensor 79. Sensor 79 senses the presence of the element and when the element has passed sensor 79 signals pump 73 to stop.

The element then passes into guide rolls 81, 82, 83, and 84 where the element is directed into the washing station. Sensor 85 senses the presence of the element, turns on pump 86 which pumps water from water pool 89 out through nozzles 87 and 88. The element passes under the spray emitted from nozzle 87 into a pool 89 of water and under the final wash spray 88. Sensor 90 senses the presence of the element and after the element has passed, it signals pump 86 to stop.

The developed element is guided onto a belt conveyor 91 by guide rolls 92 and 93. Belt conveyor 91 is carried by rollers 94, 95, and 96 and it transports the element through the final processing stages. Motor 108 is the driving system for the belt 110 which passes over a pulley (not shown) on the end of roller 94. Sensor 97 senses the presence of the element and opens solenoid valve 98 to allow gum arabic to run from container 99 onto the passing element. At the same time sensor 97 also activates brush motor 100, driving low-speed brushes 101 and high-speed brush 102 which smooths out the gum arabic and polish the surface of the element. Doctor blade 103

scrapes off any excess gum. Sensor 109 senses the presence of the element and shuts off brush motor 100 and closes solenoid valve 98. The element then passes under roller 104 and into the postexposure station.

The postexposure station is made up of sun lamps 105 surrounded by a shield 106. The sun lamps harden the photopolymer image on the element making the element a more durable printing plate. The completely processed element, ready for use, is discharged under exit roller 107.

Belt 91 is made to travel through water trough 111 where the belt is washed off and cooled.

Many modifications are possible in the construction and arrangement of this machine. The spray nozzles used may be such as to produce a square or circular pattern arranged to overlap or even to impinge on the same area. The air cylinders may be replaced with electrical valves or a hydraulic system accompanied by an appropriate logic system. The microswitches may be replaced with photocells or any other type of detector which will detect the presence of the element. The drying and postexposure stage may actually be accomplished in two stages. That is, the element may be first dried by an appropriate set of dryers such as an electrical or air drying system and then subjected to an appropriate actinic source for post exposure.

The advantages of this apparatus are that uniform, easily controlled and reproducible processing is achieved with machine processed elements showing higher contrast while retaining and improving tonal range. The surface of the non-postexposed polymer is not subjected to abrasion or accidental damage. The postexposure stage hardens the photopolymer surface for printing use and coating with gum arabic, which occurs immediately after developing or postexposure, reduces the time that the bare aluminum is exposed to the atmosphere and, therefore, reduces the chance for the aluminum to oxidize. Oxidized aluminum tends to be ink receptive and this would destroy the quality of the printing plate. Furthermore, when gum arabic is applied the surface of the element has little or no chance of being dirtied or scratched while unprotected. It was found that processing time was half that required for a hand processing technique. Skilled personnel are not required to operate this apparatus.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus for preparing a printing plate from an exposed photopolymerizable element which comprises
 - a. a developer bath unit located to receive said element;
 - b. means for spraying developer solution upon said element before it enters developer bath in said unit;
 - c. a water bath unit for rinsing said element after development;
 - d. means for spraying water on said element as said element leaves the water bath;
 - e. means for passing said element through said baths and past said sprays, comprising a pair of opposed coating drive rolls adapted to positively force said element through the developer bath and another pair of opposed coating drive rolls adapted to receive said element from said developer bath and to positively force said element through said water bath, the distance between the pairs of drive rolls being less than the length of the element;
 - f. each bath unit having a concave bottom guide plate as the sole guiding means in the bath in the unit for guiding the element in a path in the bath; and
 - g. means associated with the water bath unit for forcing the element into a different direction as the element leaves that unit;

there being a sensing means and a reciprocating roll means located after each pair of drive rolls to detect the passage of said element and to initiate movement of said reciprocating roll to direct said element to said guide means in each bath.

2. An apparatus as in claim 1 where a conveyor means is located after said water bath to receive said element and a lighting means positioned is above said conveyor means to postexpose said element.

3. An apparatus as in claim 1 where a self-cleaning conveyor means is located after said water bath to receive said element and an applicator means is positioned above said conveyor to coat said element with a preservative.

4. An apparatus as defined in claim 3 where a lighting means is positioned above said conveyor to postexpose said element.

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